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Spraying the Apple Orchard

The Time to Spray for the Codling Moth

By E. Dwight Sanderson, T. J. Headlee
and Charles Brooks

NEW HAMPSHIRE COLLEGE

OF

AGRICULTURE AND THE MECHANIC ARTS

DURHAM

CONTENTS.

SPRAYING THE APPLE ORCHARD.

BY E. DWIGHT SANDERSON, T. J. HEADLEE, AND CHARLES BROOKS.[1]

THE APPLE INDUSTRY IN NEW HAMPSHIRE.

The southern half of New Hampshire is naturally adapted to apple growing. The roadways are lined with seedlings and the pastures are dotted with old trees, many of them over half a century old, neglected, and broken down, but still bearing fairly good crops, which are allowed to rot beneath them. Indeed, much of the present apple industry of the state is due to the persistence with which Nature seeks to show the natural adaptation of the soil to the seedling tree.

FIG. 1.—"The pastures are dotted with old trees."

But New Hampshire is not known for its fruit, only 1.4% of its farms deriving their principle income from fruit. Dairying and live stock are the chief agricultural interests, to which is devoted 61% of the improved acreage.

In view of the comparatively small interest shown in fruit-growing in contrast to the great natural opportunities, it is well to inquire into the present conditions of apple culture in New Hampshire; for from a knowledge of present conditions we may be able to discern the possibilities of the future and the means of their realization.

[1]This bulletin is written by the senior author and is based on work planned and directed by him. Doctor Headlee had immediate charge of all the work upon the life history and habits of the codling moth and the records of orchard experiments, and Mr. Brooks prepared the portion concerning apple diseases.

The total apple crop of New Hampshire in 1899[1] was 2,034,398 bushels, producing most of the total value of its orchard fruits, $707,729, as 94.8% of all orchard trees were apples. In 1870 the fruits of the state were worth $743,552, so that the value of the fruit industry has remained stationary for thirty years. In 1889 there were 1,744,799 apple trees and in 1899, 2,034,398, or an increase of 16.6% in their number, but the gross amount of fruit decreased 13.3%, and the amount of fruit per tree decreased from 1.25 bushels in 1889 to 0.97 bushels in 1899, or 22%. According to all statistics, the crop of 1899 was better than that of any year since 1900. Accurate statistics since that time are not available, except the amount shipped over the Boston & Maine Railroad in 1902, kindly furnished by its freight traffic manager, which was 523,280 barrels. If 20% of the crop was consumed on the farms, then the total crop of 1902 was probably about 654,000 barrels, or about the same as 1899, 659,599 barrels. The only available estimates of the New Hampshire crop since then, made by the *New England Homestead*, indicate that the crop has steadily decreased since 1900. It would seem, therefore, that the average full crop is about one bushel per tree. The average crop per tree for Pennsylvania is two bushels, of Ohio and New York, 1.6 bushels, and the leading counties of New York produce two bushels per tree, these being the three leading apple states. The average for the United States is 0.87 bushels per tree, so that New Hampshire is just a little better than the average of the country. But what sort of a crop is one third of a barrel per tree in a good apple year? How does it happen that such is the average of the state? Observe the proportion of the total number of apple trees which are falling down over our stone walls and encumbering our pastures with what might be good fire wood, and you have the answer.

[1]The statistics are all taken from the Twelfth U. S. Census unless otherwise noted. See Bulletin 113, 12th Census, Agriculture, N. H.

Again in 1899 there were seventy apple trees per farm in New Hampshire, more than in any state except Maine, and yet less fruit per farm was produced than in any of the North Atlantic states except Maine and Vermont, this being a direct result of many trees poorly cared for. With about 5% of the improved acreage of our farms in fruit, about 4½% of the net income of the average farm came from that source and amounted to an average of $27.15. But this 5% of the improved acreage, which would be 1.85 acres per farm, is not the actual condition, for an orchard of sixty trees is not seen on the average farm, but is merely computed upon the basis of the usual number per acre from the number of trees for each farm which are scattered along fences and roads. Were these trees all in orchards, the income yielded would be at least doubled, for they would then be cared for. The income from fruit is but $13.58 an acre, only hay at $10.30 per acre yielding less, and cereals—to whose growth New Hampshire is admittedly not best adapted—bring a return of $18.29 per acre. A good fruit grower hardly considers a tree worth the ground it stands on which does not yield at least a barrel a year, or $30 per acre. Why, then, with the present trees and prices should not the average New Hampshire farmer receive $70 for his fruit crop instead of $27.15?

Many of our apple trees were planted fifty years or more ago, when the chief market was the cider mill. Then, quantity was of more importance than quality. Today the reverse is true. The best profit today is only secured from first-class fruit. The great American public is hungry for apples, and it will pay well for the best. It is well known that for the past few seasons Western apples have been selling in the Boston and foreign markets far above those of the average New England grower. Indeed, a well-known Liverpool firm has recently been quoted[1] as stating that for the past five seasons, "Boston" apples, those

[1] *New England Homestead*, November 18, 1906, quoting Woodall & Co.

coming from New England except Maine, have averaged 50 to 75 cents a barrel less on the Liverpool market than the same varieties from Maine, New York and Canada, this being attributed to the better quality, freedom from insects and diseases, and better packing of the fruit from the latter states. There is always a good market for the best; the market for the ordinary fruit is always precarious.

While apple growing in New Hampshire has evidently been standing still or declining, large regions in the East and West have planted millions of trees, whose crops are being shipped to eastern and foreign markets at a profit. New England land is cheaper, the markets are at its door, and no portion of the United States is better naturally adapted to apple culture. Indeed the most prominent and extensive fruit growers are now planting largely in New England and are outspoken in their praise of southern New Hampshire as an apple section not to be excelled, being, as J. H. Hale puts it, "the natural home of the *good* —not the 'big'—*red apple.*" How, then, shall these natural resources of the Granite State for apple growing be developed?

WHY SPRAY?

In our attempt to produce a larger and better apple crop, two methods are available. We may use more fertilizer or manure, cultivate more frequently, and prune more intelligently, and thus grow more fruit and of better quality; or, second, we may prevent the destruction by insects and diseases of the fruit grown. A very appreciable benefit will be derived from either of these methods used alone, but only by employing both of them will complete success be achieved. Far more fertilizing, more culture, and more pruning are needed in New Hampshire orchards, and without them the sprayed apple will be too small and the total crop will be too meager to be most profitable, even though sprayed and free from insects and diseases. But whereas most growers are familiar with the methods which should be employed to

grow a crop, even if they do not always use them, but few understand the value of protecting the fruit from its enemies, how much fruit is destroyed by them, and how this loss may be prevented. Thorough spraying rightly managed will prevent these losses and is, therefore, a necessary operation in all successful fruit culture.

"But," you say, "my fruit last year was practically as good as my neighbor's, who sprayed." Possibly so if you refer merely to the quality of that picked, and if your trees bore a good crop. But did you notice that the sprayed trees probably bore a barrel more fruit than yours, though all were equally well set in the spring, and did you observe the larger number of wormy and diseased windfalls under your trees than under those sprayed? These are factors not ordinarily considered. And again, when you have but a light crop, do you then have as good fruit as your neighbor who sprays, for in the off year the worminess of the fruit is much more apparent and as the price of the fruit is better, it is better appreciated? Indeed, if you will consider the matter, doubtless you will agree that one can never predict whether the fruit will be unusually wormy or diseased or entirely free from such defects, in any individual season. The necessity for spraying regularly is therefore apparent. Injury from insects and diseases must be *prevented,* rarely can it be stopped after it has become noticeable.

The necessity and profit of spraying have come to be realized by all successful fruit growers in the great fruit belts of the country. Many of them would not undertake to raise fruit without a spray pump, for the profit in apple culture is in producing a quality of fruit which will sell a little better than the average price, and such fruit must be sprayed. But in New Hampshire there are probably not a score of men who spray regularly and intelligently. Those who have sprayed but one or two seasons do not need urging to continue spraying, for they have found that the silvery spray is transformed into silver dollars by fall.

Yet there are many doubters who must be *shown.* To demonstrate to the latter class that spraying is necessary and profitable in New Hampshire as well as elsewhere, and also to determine various points as to the best materials and methods of spraying, we have conducted spraying experiments in five different orchards at Durham, Greenland, Hancock and Walpole. About 150 trees, in all, were sprayed. All of the fruit, both windfall and picked, for the whole season was counted from each tree and the condition of the fruit carefully noted, over half a million apples being handled. The results, which are given below (page 28) should certainly convince the most skeptical of the loss we annually incur by not spraying.

Spraying Controls both Insects and Diseases.—Spraying is directed against both insect pests and plant diseases. The kind of spray and the time of its application depend upon the enemy to be combated. The arsenical poisons will control the biting insects and the fungicides, such as Bordeaux mixture, prevent the growth of fungous diseases; used together they control both classes of enemies when rightly applied. Mere spraying is of no more value than feeding a healthy man on medicine and profitable results are secured only by spraying against some particular pest and applying at the necessary time the spray that will control it. The insect pests and fungous diseases of the apple must, therefore, be kept distinctly in mind and we must have a knowledge of each, if we are to combat them successfully.

THE CODLING MOTH.

What small boy does not know the wormy apple almost by intuition? And, if he fail to announce to his companion that "there ain't goin' to be no core" it is probably because the codling moth has already devoured that toothsome morsel. Of all the insects affecting the apple, this is the one against which our spraying is chiefly directed. Scores of insects attack the foliage and occasionally require

special treatment, but if the trees are regularly sprayed for the codling moth, these leaf-eating pests are usually kept under control. Only two others commonly attack the fruit, and these are easily distinguished. The plum curculio, often called the "Little Turk" from the cres-

FIG. 2, *a*.—The work of the apple worm in a small apple which may be confused with *b*, the work of the plum curculio. The apple worm eats the core; the curculio does not.

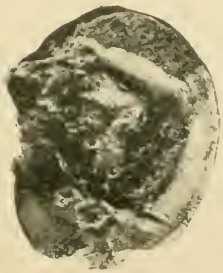

FIG. 2, *b*.

cent-shaped mark it leaves on the fruit, attacks the young fruit and its footless fleshy grubs may be found in a very large part of the windfalls during July. Its work may be recognized by its grub feeding in the flesh of the fruit around the core, while the codling moth larva bores directly to the core where it relishes the seeds. Another pest of summer and early fall, and sometimes even winter apples, is the apple maggot, or "railroad worm." Apples at-

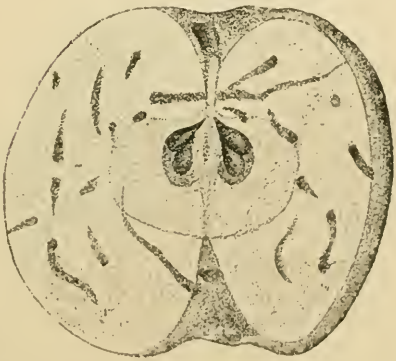

FIG. 3.—An apple "railroaded."

tacked by it often do not betray its presence until they are opened, when it is found that the flesh is honeycombed with the brownish tunnels of the small white maggots, or "railroaded," as commonly termed. In many orchards the apple maggot has become so serious that it is almost impossible to secure a crop of summer or early fall apples, but rarely does it do serious injury to winter sorts. The codling moth, whose larva or caterpillar is our common, old "apple worm," is therefore the chief enemy of the apple crop. Just how much damage it does is not generally appreciated, we fear, but the records below will make this more apparent.

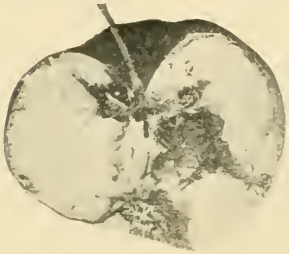

FIG. 4.—Typical work of the apple maggot.

But if this old pest is worth fighting had we not better secure a more intimate acquaintance with it, so that we may better combat it, and, perhaps incidentally, we may find that it has a most interesting career.

How the Winter is Passed.—Did you ever find out just what that little downy woodpecker is doing in your orchard, tapping away all winter? If not, it is high time you did, for he is the arch enemy of the codling moth and were it not for his good offices in destroying the larvæ in the winter your apple crop might frequently be a failure. Pick off the piece of bark at which he has been picking and you will doubtless find that a clean

FIG. 5.—"A clean hole drilled through the bark into the empty cocoon."

hole has been drilled through it and directly into a small, white cocoon, now empty. Further search, if it be made in winter or spring, will show that probably three fourths of these cocoons have been entered by a woodpecker. But after some search a few will be found containing the pinkish apple worms, the larvæ of the codling moth, snugly curled up in their silken chambers. Here they remain until spring, providing our friend the woodpecker does not find them before. Such is the usual winter home of the apple worm, but often it may form its cocoon under an old fence rail, in an apple barrel or bin, or wherever it happened to emerge from the apple in the fall and found a conveneint, sheltered spot. These wintering larvæ are of various sizes, a few being hardly one fourth the size of the largest, but only the large, full-grown ones survive and transform the next spring.

FIG. 6.—The apple worm in its winter home, the cocoon under a bit of bark.

The Transformation.—Late in April or sometime in May, the caterpillar opens the end of the cocoon and spins a silken tube from it to the surface. Then retiring to the cocoon with its head towards the doorway, it sheds its winter clothes, transforming into a pupa or chrysalis. The pupa is a semi-dormant stage in which the insect has almost no power of motion, and shows but little sign of life, but during which wonderful changes in its structure are going on, so that from the old tissues of the worm-like larva are formed the organs of the active, winged moth. In 1906 pupation commenced May 7, and the last larvæ did not pupate until early in June. About

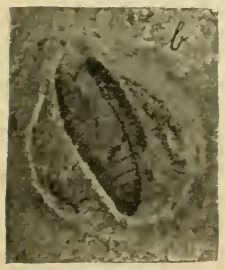

FIG. 7.—The pupa or chrysalis.[1]

[1] Figures 7, 8, 9, 14, 16, from Slingerland, Cornell University Experiment Station, Bulletin 142.

FIG. 8.—Numerous cocoons containing pupæ under bark.

twenty (20) days later the pupa wriggles itself out of the cocoon through the silken tube made by the larva, its skin splits down the middle of the back and from out the pupal shell crawls the adult moth, somewhat bedraggled, but soon ready for flight. Last year the first moths emerged about June 10, most emerging about ten days later, and the last not until July 1.

The Moth.—Though one of our common insects, the codling moth is rarely seen; for it flies at night and during the day it remains motionless on or under the bark, which it so closely resembles as to be invisible. We have photographed one with its wings folded on its back in the usual position, resting on a piece of apple bark. Can you see the moth? The moth "is a beautiful little creature," says Professor Slingerland, "whose front wings, when seen at a little distance, have somewhat the appearance of brown watered silk; when closely examined they will be seen to be crossed by numerous lines of gray and brown

FIG. 9.—The codling moth.

FIG. 10.—A codling moth on a bit of bark, which it so closely resembles as to be almost invisible.

scales, scalloped something like the plumage of a bird. Near the hind angle of each front wing there is a large dark brown spot marked with streaks of bronze or gold. The hind wings are of lighter grayish-brown color, darker toward the outer margin." The moths fly mostly during the early evening and if the evenings be warm when they emerge, the females commence to lay their eggs at once; but if cool, they may wait for ten days or so without laying.

FIG. 11.—One of the large cages used in the study of the apple worm.

The Egg.—In confinement the eggs are all laid in a few days or a week, but out of doors the females continue laying for nearly a month, depositing in all from twenty to seventy eggs, the average number being about fifty. The egg-laying habits of the moths were studied with great care the past season, and will be observed again next summer. Among other methods used for securing an exact knowledge concerning them, was that of erecting a large cage covered with cheese cloth over a ten-year-old apple tree and introducing in it a single pair of the codling moths. Before doing so every leaf on the tree was carefully examined to be sure that no eggs had already been laid. The leaves and fruit on the tree were then examined at frequent intervals, every fruit and leaf being examined and each egg marked with a tag as laid. This enabled us to determine exactly when and where the eggs were laid, how far they

FIG. 12.—"The individual egg upon the fruit looks much like a small white blister." Natural size.

were from the nearest apples, and other points, all of which have a practical bearing upon combating the pest, as will be seen below. Three of these large cages and numerous smaller ones covering individual limbs or twigs were used last season. It was found that practically all of the eggs were laid upon the leaves, upon the upper or under surface indiscriminately and a few, less than one twentieth, on the apples and bark. In 1906 the first eggs were laid June 10 and the last about July 1.

FIG. 13.—The egg on a leaf—greatly enlarged.

The individual egg upon the leaf or fruit looks much like a small white blister, about the size of a pinhead. It is at first quite transparent, but later a blackish streak is seen, showing the caterpillar forming within. The eggs are seen with difficulty and are found only by the most careful search. They hatch in from five to ten days, depending upon the temperature, those laid in the middle of June hatching ten days later, and those laid June 29 in five days.

The Larva, or Apple Worm.—The young apple worm is at first only about one sixteenth of an inch long, of a whitish color, with a shining black head, and with distinct, blackish tubercles on the back, which become quite obscure in later life. As soon as the young worm crawls from the egg it usually makes a frugal breakfast upon the tender part of a leaf, preferably at the juncture of the veins on the under surface. Indeed, occasionally a worm may

FIG. 14.—The young apple worm—greatly enlarged.

feed entirely upon the foliage and transform without entering an apple, as we have reared them upon tender water-sprouts. But this probably rarely occurs in the orchard, except, perhaps, when but little fruit is available. Very soon his appetite for green apples commences to assert itself, like that of the small boy, and he commences to search for young

FIG. 15.—The young apple worm feeding in the calyx cavity of the apple.

fruit. It was formerly supposed that most of the eggs were laid upon the apples so that the young apple worm merely had to eat its way in; but our observations show that many of the eggs are laid three, four or five feet from the nearest apple. Indeed, a considerable proportion, some-

times a fifth to a third of the eggs, are laid upon limbs which bear no apples whatever. Of course those so far from apples fail to reach the craved food and doubtless most of them perish in the attempt, for we found there was an egg within about ten inches of nearly every wormy apple, whereas most of the worms which enter the apples probably come from eggs on the leaves clustering around the apple and the young worms do not have to crawl over four or five inches. Upon reaching the nearest apples about two thirds or three fourths of the worms enter them through the blossom end, feeding a little in the calyx cavity to appease their hunger after the long journey, and then boring directly for the core. This feeding in

FIG. 16.—The "worminess" of the apple shown at the calyx.

FIG. 17.—Showing the work of an apple worm which entered at the calyx and left through the side.

the blossom end is of the utmost importance in enabling us to destroy the young worm by spraying, as will be indicated later. The rest of the worms enter the fruit through the side, often where a leaf or another apple comes in contact. The seeds of the apple seem to be most relished by the ap-

ple worm, for it soon hollows out each of them as well as the surrounding core, its work being indicated by the well-known excreta thrown out at the calyx, showing the "worminess" of the apple. In about a month, having attained full growth, it eats its way out through the side of the apple, through which a round exit hole is left, and seeks a place in which to form the cocoon. The full-grown apple worm is about three fourths of an inch long, of a whitish or often pinkish color, and so well known as hardly to require further description. Last year the first larva left the apple July 25 and the first cocoons were found about August 1st. From that time until late in September, just before the apples were picked they continued to emerge and form cocoons, the larger number being formed late in September. The cocoon is formed under the bark, or in other sheltered situations, and there the larva passes the winter, as already described.

The Second Brood.—Out of several hundred larvæ in cocoons collected during August and September, none transformed and all are now passing the winter. But the last week in August young worms, evidently just hatched, were found eating on the surface of the fruit. For some reason no eggs from which this second brood hatched could be found, but there can be no question that some of the larvæ which first matured in July transformed to pupæ and moths, the same as they do in the spring, and that these moths laid eggs for a second brood. How many larvæ so transform, and where and when the moths lay their eggs, remain to be observed next season. Evidently the eggs are laid upon or very near the apples, for larvæ which had just hatched were found upon them. The feeding habits of these little worms of the second brood are quite different from the main summer brood, as they merely feed upon or just under the surface, often around or in the calyx, or where a leaf or another apple comes in contact with the skin, and rarely bore into the apple, as does the first brood. Rarely do

these worms of the second brood become full grown in this latitude, but late in September, when half grown, they form their winter cocoons. It is for this reason that in examining the cocoons in winter some larvæ are found hardly half the size of the majority of those full grown of the first brood. The difference in the food habits of this second brood has been observed by many growers and has led some to the belief that the work is that of a different insect. Although but less than five per cent., and probably only one or two per cent. of the larvæ transform to the second brood

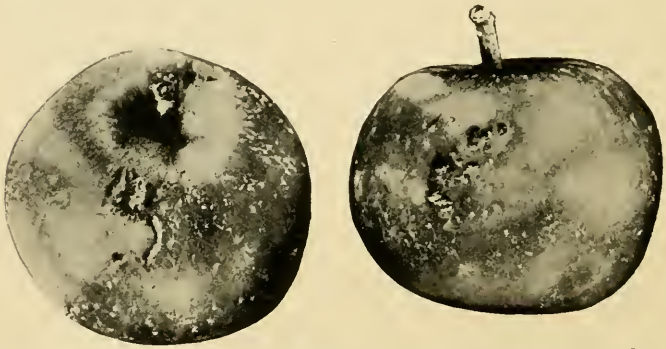

FIG. 18.—"The little worms of the second brood feed upon or just under the surface."

of moths, yet we find that fully two thirds of the picked fruit which shows the work of the codling moth has been affected by the second brood, which have marred the surface or eaten around the calyx, and only about one third of those wormy show the characteristic work of the first brood. Indeed, the bulk of the apples attacked by the first brood fall to the ground as windfalls, and thus the damage done by it usually escapes notice.

SPRAYING EXPERIMENTS IN 1906.

Our field work in 1906 was planned both as *experiments* to show the best time to spray and the best materials to use, and also *demonstrations* to show the value of spraying in different localities in southern New Hampshire. The results of such *experiments* secured from a single season's

work are usually not to be relied upon until they have been repeated for two or three years so that there can be no doubt as to the uniformity of the results. The experiments will therefore be repeated one or two years more, when a complete and detailed report of the whole work and definite recommendations based upon it will be published. But as a *demonstration* of the general profit of spraying, with the methods usually employed, the work was a complete success and merely confirmed the results secured by hundreds of experimenters and practical fruit growers throughout the country, and demonstrates that spraying pays in New Hampshire as well as elsewhere.

In all these experiments the trees were sprayed in practically the same way as described below (pages 47–52), each being given two sprayings with arsenate of lead or Paris green and Bordeaux mixture, just after the blossoms dropped and again a week later. All of the windfall fruit was picked up from under each tree and a record made as to whether it was wormy or not and a similar record was kept of the picked fruit. Thus it was possible to know the exact number of fruits which each tree bore during the season, what proportion dropped and how many of both dropped and picked fruit were injured by the codling moth. Altogether over half a million apples were thus examined and recorded.

To render the results of this work more readily understood, we have had prepared the accompanying figures, which show the amount of fruit on both sprayed and unsprayed trees in each locality, with the proportion on the trees when picked, the amount which had dropped and the part of each which was wormy. The estimates of the value of the spraying are secured from the value of the picked fruit which was not wormy. The amount of picked fruit not wormy was secured by multiplying the total average number of fruits per tree by the percentage of the total crop which was not wormy and picked. Six hundred apples were considered a barrel, as this was the average for

the picked fruit. One dollar per barrel is taken as the net value of picked apples that were not wormy—most of which would be No. 1 fruit. This is probably slightly below its actual value in 1906, for the market price ranged from $1.75 to $2.00, while barrels, picking and packing, would hardly cost more than sixty-five or seventy cents. Incidentally it might be noted that this is the average price for winter apples on the Boston market for the past fifteen years, October 15.

Spraying at Walpole, N. H.—Three Baldwin and six Rhode Island Greening trees were sprayed in the orchard of H. H. Thompson, the record of fruit on five unsprayed trees being kept for comparison. The trees bore and average of about 2,600 apples each for the whole season. Of these one half dropped from the unsprayed trees, while only one fourth, or half as many, dropped from the sprayed trees, about one third of the dropped fruit being wormy in each case. Of the 50% of the total crop which was picked from the unsprayed trees, 19% was wormy, leaving 31% of the total crop of the tree as picked fruit free from worms, which would be about one and one-third barrels (1 1-3) worth $1.33 net. On the sprayed trees but 11% was wormy, and as three fourths of the fruit remained on the trees, there was picked 65% of the total crop of the season, free from worms, or about 2 4-5 barrels, worth $2.80 net. Thus considering merely the value of the unwormy picked fruit, which is mostly No. 1, there was a gross profit of $1.47 per tree, and as the spraying cost about twelve cents a tree, a net profit of $1.35 per tree.

Spraying at Hancock, N. H.—Twenty-five Baldwin trees were sprayed in the orchard of C. E. L. Hayward, and a record was kept of five unsprayed trees. The trees bore an average of about 3,600 fruits per tree for the whole season. About one fourth (26%) dropped as windfalls from the unsprayed trees and an almost equal amount (24%) from those sprayed. But of the fruit remaining on the trees and picked, 28% was wormy on the unsprayed

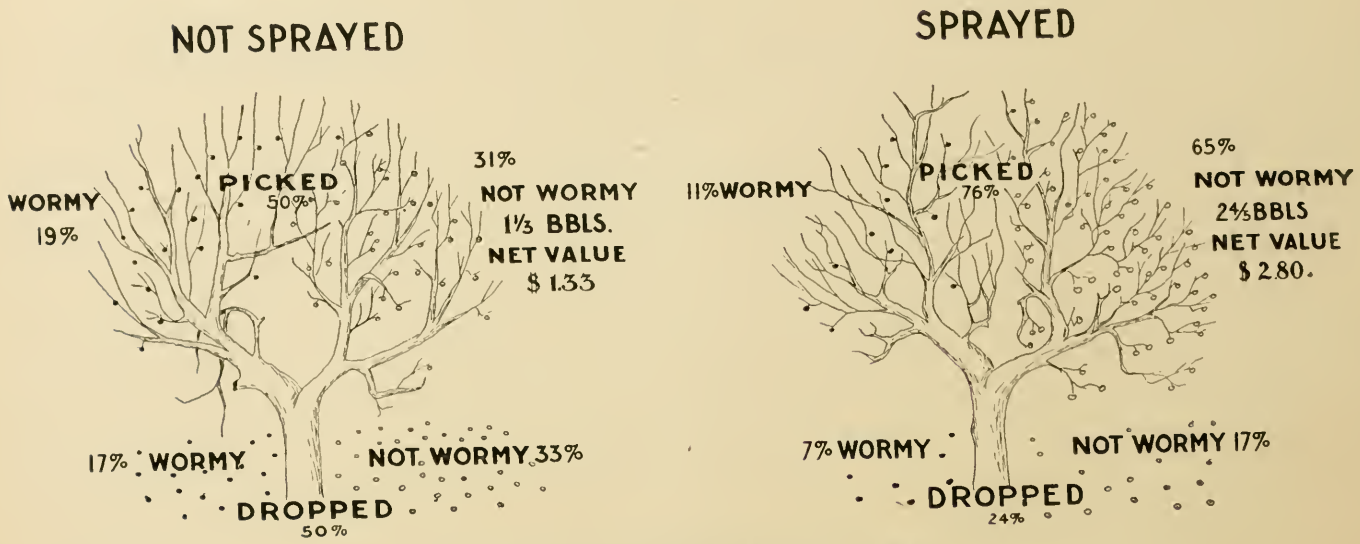

FIG. 19.—Result of spraying at Walpole, N. H., in 1906.

trees, while only 5%, less than one fifth as much, was wormy on those sprayed. Thus on the trees not sprayed 53% of the total crop was picked free from worms, making 3 1-5 barrels, worth $3.20 net, while on those sprayed 72%, or nearly half as much more, was picked free from worms, making 4 1-3 barrels per tree, worth $4.33 net. Deducting the cost of spraying, there was, therefore, a net profit of just $1.00 per tree.

Spraying at Greenland, N. H.—Twenty-eight Baldwin trees were sprayed in the orchard of William H. Weeks, the records of five unsprayed trees being made. Unfortunately the records of the number of picked fruit were accidentally destroyed of all except four sprayed and three unsprayed trees. These trees, however, were scattered among those sprayed, and show a very fair average of the condition of all; indeed, they show rather less benefit than many. This orchard was much worse infested with the codling moth than those at Walpole or Hancock, though the orchard was fully as well kept. From the unsprayed trees three fourths of the fruit dropped as windfalls, while on those sprayed but 15%, or one fifth as many, dropped. Of the fruit left to be picked on the unsprayed trees, two-thirds was wormy, leaving but 8% of the season's crop to be picked free from worms, making about one-half barrel, worth fifty cents net. On the sprayed trees only 1-11 of the picked fruit was wormy, leaving 70% of the total crop to be picked free from worms, making 4 1-5 barrels, worth $4.20 net. These trees bore about 3,600 apples per tree for the season. On eight other trees from which the record of the picked fruit was secured, but two to four per cent. were wormy. Thus these trees would show $3.70 worth more fruit on the sprayed trees, which means a net profit of at least $3.55 after deducting the cost of spraying, from the control of the codling moth. Such would be the value of the spraying were all the unwormy picked fruit of good size and not otherwise injured, but in this orchard much of the picked fruit free from worms was too small for No. 1 size

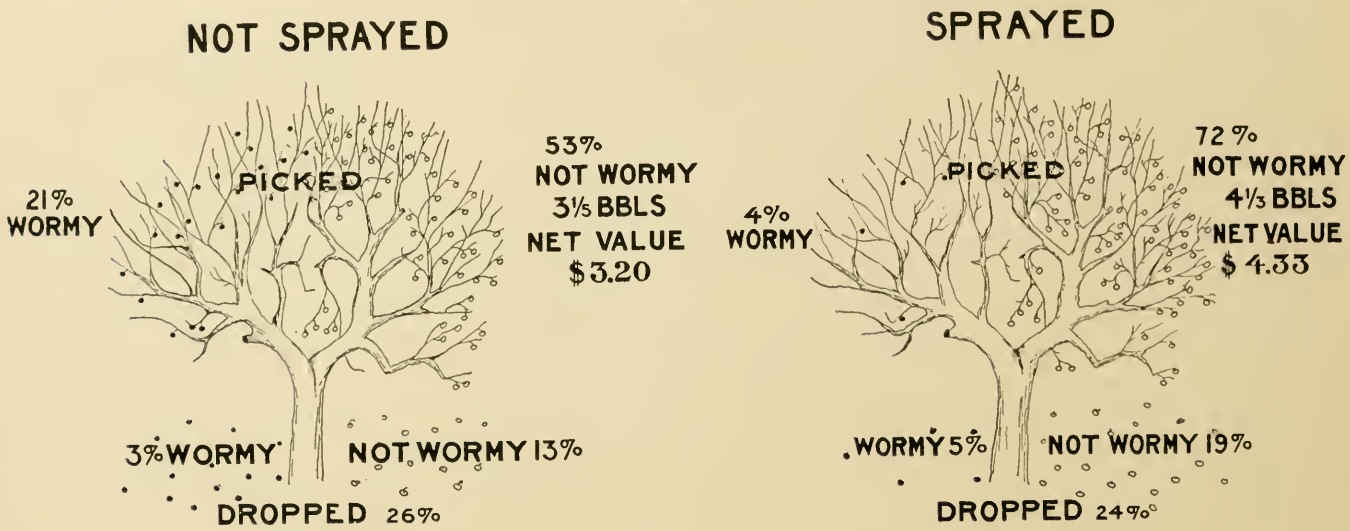

FIG. 20.—Result of spraying at Hancock, N. H., in 1906.
(Wormy dropped fruit on tree not sprayed should be 13 per cent. instead of 3 per cent.)

and much was otherwise blemished. A record of the number of barrels of No. 1 and No. 2 fruit from both sprayed and unsprayed trees was kept, and showed that 3 1-5 barrels were secured from each sprayed tree, against 1 4-5 barrels on each of the unsprayed trees, or a net gain of 1 2-5 barrels, worth $1.40 net. Deducting from this the cost of spraying, we have a net profit of around $1.25 per tree as the actual profit. Had the orchard been well fertilized and cultivated so that the trees could have matured the large crop they bore, as full size apples, a profit of over three dollars per tree would have been actually realized. This shows that spraying is but a part of successful apple culture, and that to secure the greatest profit from it, the orchard must be well cared for otherwise. Even larger profits may be expected where fruit of the best size and quality is grown, for in our experiments in Delaware orchards in 1901 and 1902[1] we showed that two to three barrels more non-wormy fruit might be picked from sprayed than from unsprayed Winesap trees, practically all of which fruit was No. 1, and that year brought about $3.00 per barrel net, thus giving a clear profit of $6 to $10 per tree from the spraying, equivalent to $2.50 to $3.75 for the same amount of fruit at the price usually received for New Hampshire Baldwins.

Comparing the results secured in the different orchards, which are a fair average of those throughout southern New Hampshire, we see that at the average price of winter apples a net profit of from $1 to $1.35 per tree may be secured from two sprayings solely from the effect upon the codling moth, for in all the above estimates no consideration has been given to the effect upon scab, brown spot, rots, etc., which will be mentioned below. Indeed, with proper care of the orchard, this profit from spraying alone should be at least trebled. Why, then, do *you* not spray? Possibly one of a thousand would-be excuses which seem

[1]See Bulletin 59, Delaware Agricultural Experiment Station, "The Codling Moth."

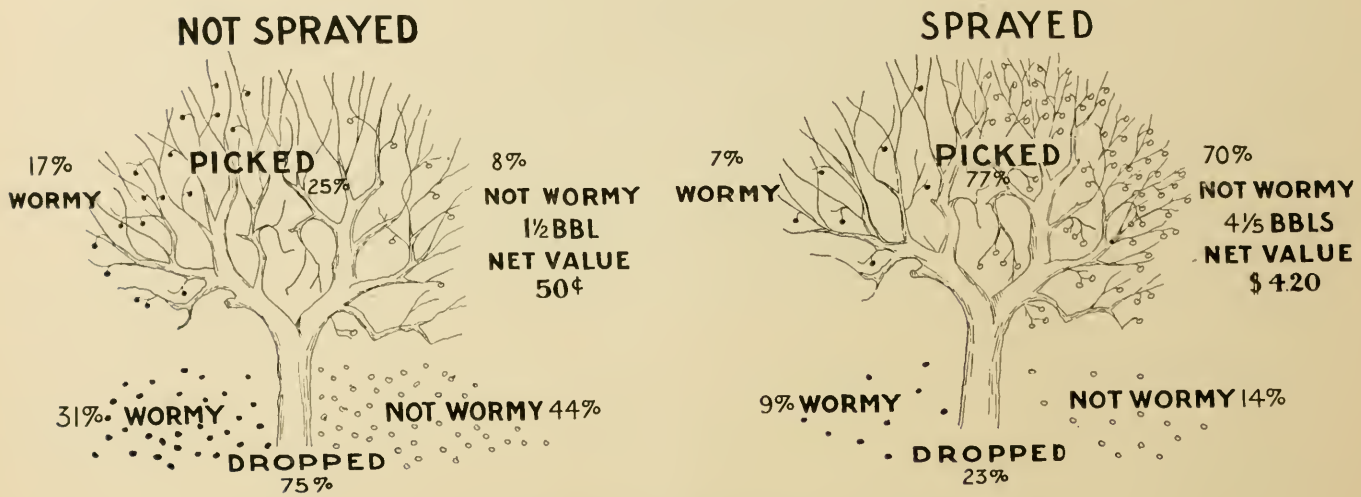

FIG. 21.—Result of spraying at Greenland, N. H., 1906.

to warrant the neglect of spraying in the minds of most of our apple growers will soothe your conscience into neglecting it next year. Is not the question of spraying, after all, like that of all "better farming," whether you are a real farmer or fruit-grower, a *producer,* or whether you are essentially a *consumer,* having planted an orchard, or possibly reaping the benefit of one planted by your father or grandfather, which gives you a biennial crop with practically no care on your part. Are you really *producing* a crop? Are you not to a large extent dependent upon the bounty of a too generous Nature? If we are to be fruit *growers* and not mere *consumers,* we must fertilize, prune, and *spray;* it is a debt owed the tree. Shall we *make* money out of fruit-growing, for which there is no better opportunity in the United States than here in New Hampshire, or shall we *take* what the trees will bear, without always even being thankful? These principles are not particularly applicable to spraying only, but are indeed those upon which all betterment of the farming of New Hampshire must rest. The great question in the improvement of New Hampshire agriculture is not whether it can be made sufficiently profitable to be worthy of the best efforts of a man of ability, for that is being constantly answered affirmatively; it is not a question of crops or methods whereby the profits of agriculture can be increased and its life made more congenial, for those questions are being, and will be solved; but it is a personal question for each individual agriculturist whether he has sufficient interest in his work as a business to devote the same intelligence and energy toward making it the largest possible success, that is required of the man successful in business, in a profession, or in manufacturing. These old farms of the granite hills of New Hampshire are waiting, ready to give a worthy return to men who, seeing the possibilities in them, delight not in "wringing a living from the rugged soil," but in so applying the laws of the science of agriculture, that the soil will be enabled to bear the largest and best of those crops to which it is best suited. For such there is a life on New Hampshire's hills well worth while.

OTHER MEANS OF COMBATING THE CODLING MOTH.

As has been noted, the woodpeckers and nuthatches annually save us barrels of apples by destroying the apple worms under the bark in the winter. They should therefore be encouraged and lured to the orchard whenever possible. Bits of suet and meat suspended from the trees will often attract them and sometimes help them through a hard winter.

FIG. 22.—"The neglected orchard."

Thoroughly scraping the bark with a sharp hoe or tree-scraper, so as to remove the hiding places of the wintering larvæ, will also materially aid in their control.

Usually nearly half of the windfall fruit is wormy, and the fruit drops before the worms are full grown. If it be left on the ground the worms emerge and form their cocoons on the nearest tree. If the dropped fruit be gathered frequently, or if enough hogs run in the orchard to keep it destroyed, a large proportion of the larvæ will be killed, and especially those which mature early and form the small second brood.

To illustrate the value of scraping the trees and keeping the drops picked up, a comparison of two orchards about a mile apart may be of interest. One had been fairly well cared for in this way, while the other had been neglected. The conditions in the latter orchard may be appreciated from the photographs. In the other the trees had been

scraped, hogs kept most of the droppings destroyed and the rest were collected and removed. Otherwise, the trees compared were not very dissimilar, neither being sprayed.

The diagram shows the records, kept the same as those of the sprayed trees, from five trees in each orchard. In the neglected orchard one half of the fruit dropped, three fourths of the windfalls being wormy, while in the other only slightly over one fourth (27%) dropped, and but half

FIG. 23.—The ground covered with the droppings of the whole summer in the neglected orchard.

of it was wormy. Of the picked fruit one sixth was wormy on the neglected orchard, while only one ninth was wormy on the other, but the wormy picked fruit formed 8% of the total crop of the tree in both cases. In the neglected orchard 42% of the total crop of the tree was picked free from worms, making two barrels, worth $2 net, while in the orchard cared for, 65% of the fruit was picked not wormy, making 3¼ barrels, worth $3.25 net, and showing a benefit of $1.25 per tree at but slight cost for scraping the trees and picking up the drops, which pay for themselves in cider. Altogether the records showed that there were but about one half as many wormy apples during the

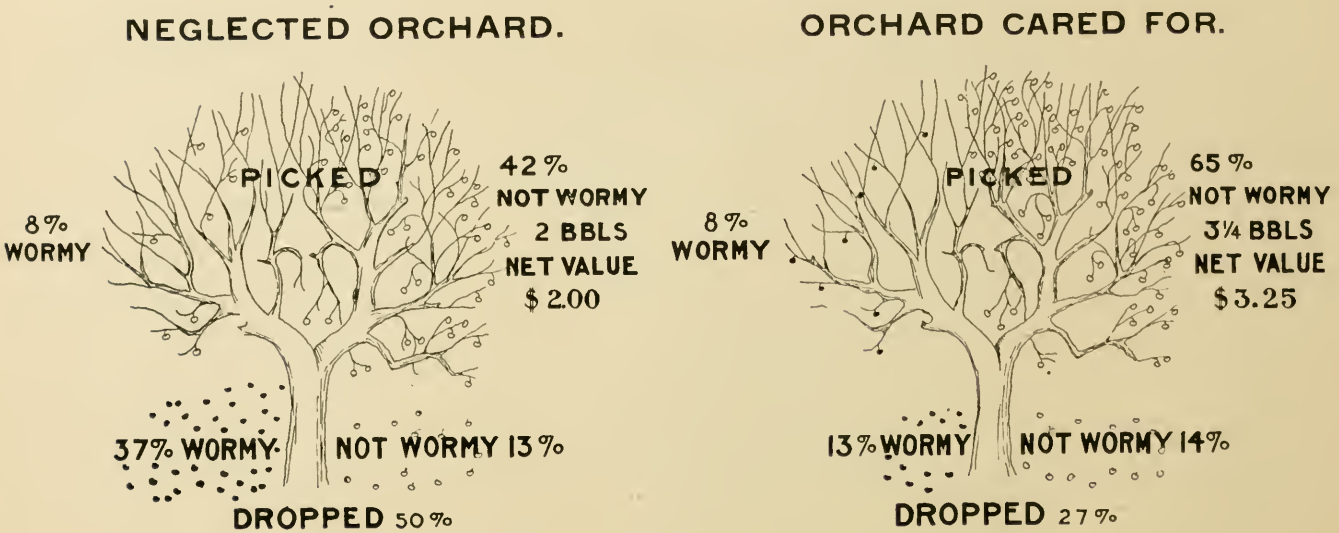
NEGLECTED ORCHARD.
PICKED
42 %
NOT WORMY
2 BBLS
NET VALUE
$ 2.00
8 %
WORMY
37% WORMY
NOT WORMY 13 %
DROPPED 50 %
ORCHARD CARED FOR.
PICKED
65 %
NOT WORMY
3¼ BBLS
NET VALUE
$ 3.25
8 %
WORMY
13 % WORMY
NOT WORMY 14%
DROPPED 27 %

FIG. 24.

whole season in the orchard cared for as in the one neglected.

Not only the neglected orchard but the neglected roadside and pasture trees, very many of them worthless seedlings, harbor all the pests of the apple, where they breed unmolested and constantly migrate to the orchard. Road surveyors should be required to cut every seedling or uncared for apple and wild cherry tree, and every property owner should replenish his woodpile with them.

HOW SPRAYING AFFECTS THE APPLE DISEASES.

Every year a large part of the apple crop of New Hampshire is of inferior quality on account of the attacks of fungous diseases. The extent and seriousness of the injury depend largely upon the weather conditions. Fungous diseases are always favored by dampness and hence are more serious in certain parts of the state and individual locations, but while the climatic conditions are so important a factor in their growth, the fungi themselves are the real cause of the trouble.

Fungi are plants which have no green coloring matter and which, being unable to obtain their starch food material from the air, as do green plants, obtain it ready made from other plants, living or dead. Those which grow upon dead plants are known as *saprophytes*, and those living upon live host plants are termed *parasites*. None of the fungi have seeds, but all of them produce spores, which serve the same purpose. These microscopic spores are exceedingly small and light, are readily carried by insects or the wind, and when they light upon a suitable host plant they may infect it with the disease. Some of these fungi, for instance the apple canker, are unable to gain entrance into healthy trees and fruit and are therefore dependent upon insect or other injuries for their start. On the surface of the leaves, fruit, and younger twigs of the apple are breathing pores, minute openings through the protecting

surface, which afford the usual place of entrance for the fungi. When the fungus has once gained entrance to the host plant there is but little that can be done to stop its further growth at that place, but it usually may be prevented from starting at other points. This may be done by killing the germinating spores before they have opportunity to grow into the tissues of the host plant. The best way to do this is to spray with Bordeaux mixture, or some similar fungicide, which is therefore a *preventive* rather than a cure. Numerous fungous diseases injure the apple, but most of them are controlled by the sprayings advocated below, and upon only two of them have observations as to the effect of spraying been made in the past year.

Apple Scab.—The scab is one of the worst of the fun-

FIG. 25.—Apples affected with scab.

gous diseases of the apple, attacking both the leaves and the fruit. It appears in the spring on the young leaves as velvety, olive spots. In severe cases the leaves become shrivelled and distorted, and finally drop off. On the fruit it produces olive-black spots, which in their later stages have a narrow margin of light gray. Scabby apples

are often dwarfed and cracked and in any case are rendered unsightly and their market value is greatly reduced. Aside from the direct injury produced by the scab, it breaks the skin of the fruit and thus opens the way for the

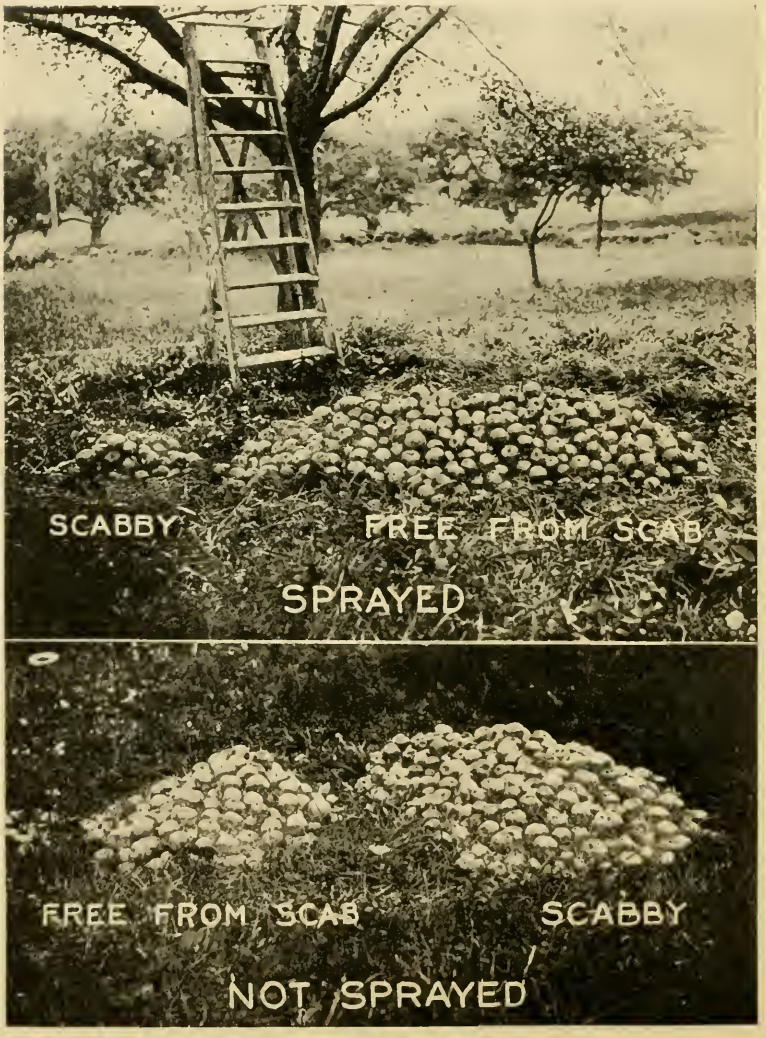

FIG. 26.—Result of spraying Macklntosh Red apples with Bordeaux mixture for the scab at Walpole, N. H., in 1906.

rot fungi, which soon destroy it. The spots on the leaves and fruit are the source of an abundant crop of spores which are able to start the disease in new places. The fungus lives through the winter in the fallen leaves, producing another form of spore in the spring. These spores are carried by the wind to the young leaves and the disease starts anew. Some varieties of apples are affected more often than others, the Fameuse and Mackintosh Red being especially susceptible and almost always scabby unless sprayed.

In comparisons made in the orchard of Prof. F. W. Hooper at Walpole, N. H., in 1906, we found that on the Mackintosh trees not sprayed 43% of the picked fruit was scabby, while on those sprayed twice with Bordeaux mixture, but 6.3% were scabby. The photo of the amount of scabby and clean fruit on two of the sprayed and unsprayed trees shows the profit from the spraying.

Fruit Spot.—Several varieties of New Hampshire apples, especially the Baldwin, are seriously affected by a fungous disease known as the "fruit spot" or "brown spot." When the apples are nearly mature small depressed spots begin to form on the surface. On the green parts of the apple the spots are deeper green; on the red portions, a deeper red. The tissue immediately beneath these spots is brown and corky. In storage the spots often become larger and more sunken, but are never over one fourth an inch in diameter. Spraying with Bordeaux mixture greatly reduces this disease, the late applications seeming to be most effective. The following data show the results obtained in the station experiments made in the orchard of Mr. Albert

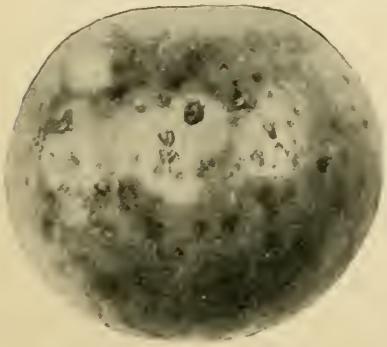

FIG. 27.—"Fruit spot" on Baldwin.

DeMeritt at Durham, N. H., the past year, confirming those of Dr. H. H. Lamson, given in former publications of this station. The plots consisted of five trees each and the number of spotted and unspotted apples on the trees at the time of gathering was determined by actual count. The Bordeaux mixture was made with five pounds each of lime and copper sulfate to fifty gallons. The "KLBP" was similar Bordeaux mixture with kerosene-limoid, as recommended by the Delaware Agricultural Experiment Station, containing 15% of kerosene.

Fungicide.	Time of spraying.	Per cent. of picked apples not spotted.
None.		0.3
Bordeaux	May 30	17.
"	May 30 and June 8	31.
K. L. B. P.	May 30 and June 21	61.
"	May 30 and June 8	14.
Bordeaux	June 2 and June 8	28.
"	June 2 and June 21	58.
"	June 21	44.

From the above it is evident that spraying just after the petals fall and again three weeks later will prevent the spot on 60% of the fruit. Probably another spraying ten days later, or about July 1, with that of June 8 and 21 would have been the best for its control, and spraying at those times will be tested next season. In any event the benefit from spraying merely in reducing this disease is sufficient to warrant its cost, without considering the profit derived from controlling the codling moth.

HOW TO SPRAY.

Apparatus.—*The Pump.* For the average New Hampshire orchard and farm a good barrel pump is the best type. The small compressed air, knapsack, and bucket sprayers are good for garden work, but do not furnish sufficient pressure for large trees. Numerous requests come

to us to recommend some particular pump. In reply we are accustomed to refer to the best pump companies and advise the inquirer to study their catalogs and then use his best judgment, after a careful consideration of the following points:

1. The pump should be guaranteed to furnish six nozzles at 75 pounds pressure with ordinary pumping.

2. It should have a good air chamber within the barrel, and not projecting above it as in some styles.

3. As little of the working parts of the pump as possible should be above the head of the barrel, as exposed parts are easily broken.

4. Pumps whose handles, etc., are made of galvanized or malleable iron are preferable to castings, which break easily.

5. The cylinder, plunger, valves and working parts should be of brass.

6. There should be a good mechanical agitator of the paddle type, preferably arranged so that it can be worked with the pump handle without operating the pump. An agitator is essential to keeping the mixture in suspension.

7. The pump should be attached to the barrel so that it may be quickly removed for repairs.

8. The valves, with their seats or cages should be readily detachable for cleaning, and should be so constructed that they will grind themselves evenly.

9. The plunger or piston should carry the packing necessary to secure a tight cylinder, rather than having the packing in the old style "stuffing box," which is more difficult to pack and causes more friction and waste of energy.

Possibly all of these points will not be found in any one pump, but the better pump companies, in their newer models, are adopting most of the above features. Such a pump with hose, nozzles and rod should cost $15 to $30. The following companies are making pumps of the type described, and they can usually be bought through agricultural warehouses, seedsmen, etc. No mention is made in the follow-

ing list of several companies making excellent pumps of other types:

Morrill & Morley, Benton Harbor, Mich.
Hardie Pump Co., Hudson, Mich.
Spramotor Co., Buffalo, N. Y.
Goulds Mfg. Co., Seneca Falls, N. Y.
Deming Co., Salem, Ohio.
Myers & Bro., Ashland, Ohio.
Field Force Pump Co., Elmira, N. Y.

The Nozzle.—A good nozzle is as essential as a good pump for proper spraying. Fair spraying may be done with a poor pump if one has a good nozzle, but it is impossible to spray with the best pump and a cheap nozzle. Many a man fails in spraying through buying some cheap nozzle which sprinkles rather than sprays. The Vermorel and Bordeaux nozzles are the types most widely used, and each have their advocates. Each are sold under various trade names, such as the Demorel and Mistry, similar to the Vermorel, and the Seneca and others the same as the Bordeaux. Usually for orchard work two or three nozzles are attached in a cluster, either by a "y," tee, or ring. The lighter the nozzles and connections, the better, so that some firms are now making them of aluminum, for at the end of a ten-foot rod they soon become heavy.

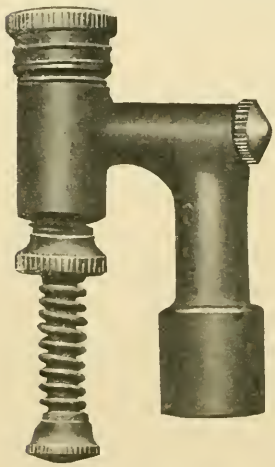

Fig. 28.—The Vermorel nozzle.

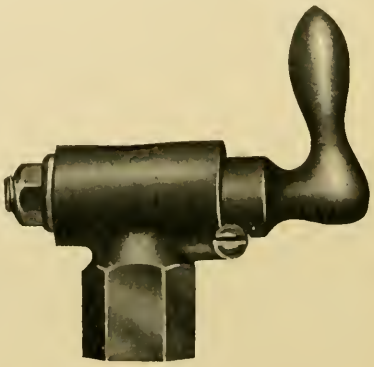

Fig. 29.—The Bordeaux nozzle.

Extension Rod.—In orchard spraying an exten-

sion rod is a necessity, especially with the tall trees usual in New Hampshire orchards. The best of these consist of a bamboo rod enclosing a light brass tube (or better, an aluminum tube which has a larger diameter) and fitted with thread for the nozzle at the tip, and with a shut-off or stop cock at the lower end, so that the stream may be cut off when moving from tree to tree and the pressure maintained. Iron and brass extension pipes are too heavy and are disagreeable to handle. Ten feet is a desirable length.

Hose.—It is economy to get the best half-inch hose (inside measure) and to have plenty on hand. Make the joints as firm as possible, and see that the shanks to the nozzles and fittings are long enough so that the hose clamps will grip them firmly. A few firms are offering improved hose couplings, but there is much room for their improvement. Nothing is more disagreeable than the constant breaking of couplings, with the incidental enforced bath in the spray mixture, and many have given up spraying in despair on account of being unable to make the cheap couplings hold the hose under pressure.

Strainers.—One of the most frequent causes of delay is the clogging of the nozzles from sediment, dirt, etc. To obviate this, when filling the sprayer strain all mixtures through a fine copper strainer, which may be purchased of any pump company. Have the barrel of the sprayer tight, and see that it is clean before starting. So-called "nozzle protectors" are now being sold by several companies, consisting of a pipe containing a fine strainer, which is attached between the outlet of the pump and the hose. When this strainer becomes clogged, by turning a two-way cock it is reversed and the stream forces the sediment out of the pipe through an aperture. It is readily disgorged and the nozzles are thus protected from any sediment which may have passed the strainer at the bottom of the pump.

The Wagon and Tower.—Ordinarily the sprayer is sim-

ply placed in a wagon box in which the one spraying stands. But as will be shown below it is essential that the spray hit the tree from above, and it is therefore necessary that the one spraying be elevated to as near the center of the tree as possible. For an orchard of less than 500 trees, an outfit such as we have used for the past two years is entirely satisfactory. This consists of a stout one-horse

FIG. 30.—Wagon and tower used in the experiments; a good type for the small orchard.

wagon, on cultivated ground two horses would be necessary, with a rough tower erected at the back of the wagon which places the one spraying on a platform about four feet above the wagon box. The platform should be as high as possible without being top-heavy, depending upon the roughness of the land, etc. Around the top of the tower is a rail to ensure the safety of the sprayer. The whole tower is readily made by anyone in a few hours, from ordinary studding and rough boards, and should be firmly

bolted to the wagon, so that it may be readily removable. An oiled canvas cover should be provided for the horse, extending over the head and tail and down below the shafts, as the Bordeaux mixture will injure the coat of the horse if much falls on it.

Where larger orchards are to be sprayed a truck and tower such as have come into common use in Delaware

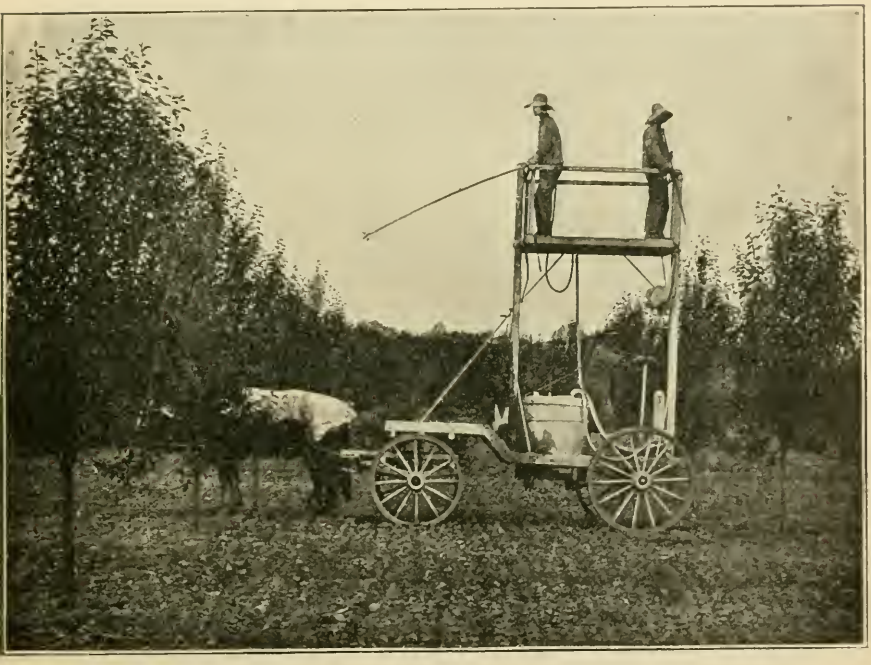

FIG. 31.—Truck and tower used by S. H. Derby, Woodside, Del.

orchards, will be found more satisfactory. The tower carries two men, and the truck a 150-gallon cask, set near the ground. Two horses are necessary, and a pump of the horizontal type, like the Sentinel, Bonanza, Planet, Friend, etc., is preferable as few barrel pumps furnish sufficient power without overworking the one pumping.

The Spray Materials.—*Bordeaux Mixture.* This is the

most expensive part of the spraying material, and therefore should be carefully made. Take fifty pounds of bluestone or copper sulfate and hang in a coarse bag in a 50-gallon barrel of water, so that when dissolved the solution will contain one pound to the gallon, or with a smaller barrel make up in the same proportion. This is the "stock" bluestone solution. Take fifty pounds of best stone or quicklime—be sure that it is fresh and has not been air slaked, and slake it carefully as for making mortar, gradually applying just enough water to slake without burning, and not enough water to flood it. When thoroughly slaked, place it in a 50-gallon barrel and fill it with water, or in similar proportions, so that the "stock" solution of lime will contain one pound to the gallon. These "stock" solutions may be kept during the spraying season, if covered. Take another barrel and cut it in two or use two tubs of any kind which will hold a half barrel each. Into one place three gallons of the "stock" bluestone solution and fill it with water, so that the half barrel of water contains three pounds of bluestone. Into the other half barrel place four gallons of the lime "stock" solution, and fill it with water so that it contains four pounds of lime. Then dip out from the two half barrels alternately into the pump barrel, stirring as they are poured into the pump barrel. Do not pour one dilute solution into the other, but pour them together into the spray barrel. Many are in the habit of placing the three gallons of stock solution of bluestone in the spray barrel and nearly filling it with water, and then adding the lime stock solution, or *vice versa.* The resulting mixture is not as good as when made as above directed, as it tends to curdle and settles to the bottom. This tendency is even more marked if the two stock solutions are mixed without dilution and then the barrel is filled with water. Always dilute the lime and bluestone mixtures as directed before mixing them together, and then stir while mixing. This ensures success. In our own operations we have employed an outfit which saves much time and labor. A rough plat-

form was built on a side hill along the roadway and near the water supply. On either side is the barrel of stock solution of lime and bluestone. In the middle is a large box lined with zinc and holding slightly over a barrel, which is raised above the platform and from the lower end of which leads a hose. On top of this tank, are two half bar-

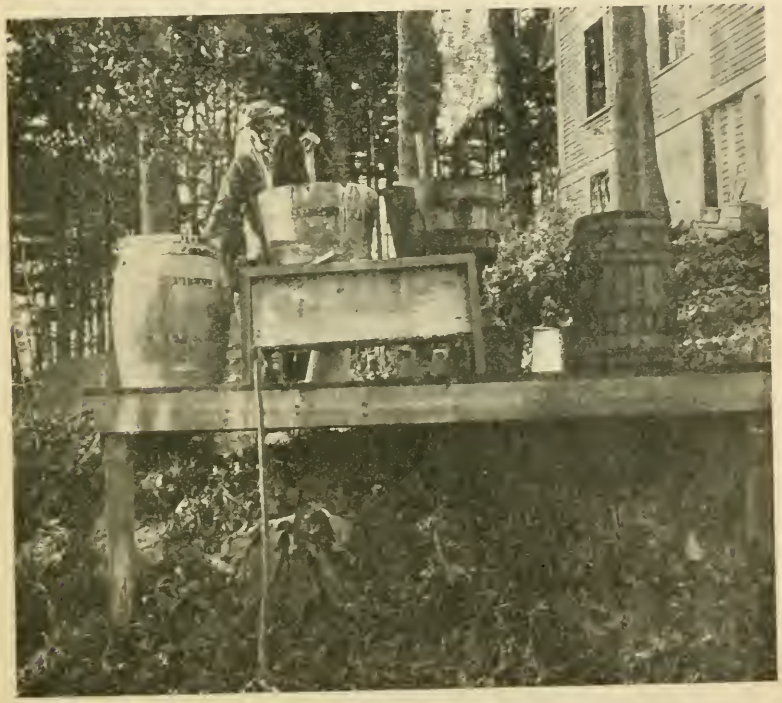

FIG. 32.—The platform and tanks for making Bordeaux mixture.

rels, each of which has a hole in the bottom plugged by a stick, which reaches up above the top of the half barrel. The stock solutions are put into either of these half barrels and they are then filled with water from the hose. The plugs are then withdrawn and the dilute solutions flow into the tank beneath, where they are stirred while mixing. When the sprayer arrives from the orchard this tank of Bordeaux

mixture is ready to be drawn off through the hose. While it is running out the two half barrels are again filled, and when the sprayer has been filled they are allowed to run into the mixing tank while the sprayer is on the way to the orchard. Thus the labor of dipping the mixtures from one barrel to the other is obviated and half the time of mixing is saved, and it is time that costs in spraying. A large hose should lead from the tank to the sprayer and the outlet of the tank should be guarded with fine brass or copper gauze or screening to prevent particles of lime and dirt escaping. The mixture should also be run through a strainer as it enters the spray barrel.

With good lime there is no reason why by following the above directions a good mixture should not be made, but it is always safest to test the mixture to see that it contains no free copper which will burn the foliage. The best test is that with ferro-cyanide of potassium or yellow-prussiate of potash. Secure five cents worth of the crystals from the druggist and dissolve in ten times their bulk in water. Add a few drops to the Bordeaux mixture. If they remain the same color, it is well made. If they turn brown, there is free copper in the mixture and more lime solution should be added until this reaction does not take place.

The above formula for Bordeaux mixture is weaker than that usually advised and than we should recommend for potatoes, but for the past few seasons, largely due to the unusual cold, wet weather in May and early June, there has been considerable trouble throughout the country with Bordeaux mixture burning the foliage and russetting the fruit when made by the standard formulas. Less injury has resulted from the more dilute solutions. Extensive experiments are now being made to determine the cause of this injury, and how it may be obviated, but until they have been completed it will be safer to use the dilute solution as described above. Probably in normal seasons no injury would result. On account of this injury in wet weather it will be well to avoid spraying while the foliage is wet or

during wet weather, except that the spraying immediately after the blossoms drop must be made while the calyxes are open, as explained below.

Insecticides.—The Bordeaux mixture is to prevent diseases of foliage and fruit; it has no value against the codling moth. For it and leaf-eating insect pests use arsenate of lead, Paris green or green arsenoid. Arsenate of lead seems to adhere to the foliage better, but costs a little more, as it should be used at the rate of two pounds to the barrel, while one-half pound of Paris green per barrel is about equally efficient, and the two insecticides cost about the same per pound. Home-made insecticides such as home-made arsenate of lead, arsenite of lime or soda, are not advised, for although somewhat cheaper there is some danger in making them, and the purity of the chemicals cannot be known by the buyer, and in many cases poorer results ensue. For the amount of insecticide which will be used in the average orchard it is better to buy it ready made, but be sure that the name of the maker is upon the package and that its purity is guaranteed. Add the insecticide to the Bordeaux mix-

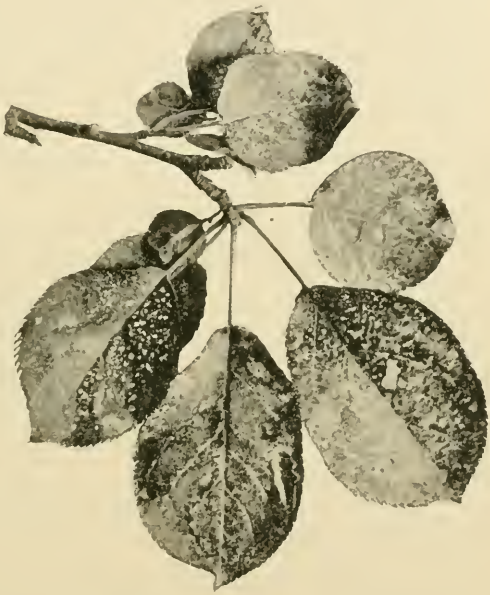

FIG. 33.—"Arsenate of lead adheres to the foliage." Leaves sprayed June 1 with spray still adhering when photographed in September

ture just before or after it is placed in the spray barrel. In adding Paris green, first mix it with a little water in a cup to form a paste and then dilute and add to the mixture. If added direct it will not mix well. Mix the arsenate of lead in the same way, and see that it is thoroughly dissolved before adding to the mixture. If Paris green be sprayed without Bordeaux mixture, always add twice its weight of freshly slaked lime to prevent burning of foliage by any soluble arsenic.

Several prepared Bordeaux mixtures, sometimes with insecticide added, are now on the market. Some of them are excellent; others are made to yield a profit to the makers, and though efficient, if enough is used, cost too much for the average grower. These prepared mixtures are being tested by us and the results will be published next year. They are desirable for the man with but half a dozen trees, but the Bordeaux mixture can be made much more cheaply by the man who is to spray an orchard.

When to Spray.—The first spraying should be made before the buds open and copper sulfate solution, one pound of copper sulfate or bluestone to twenty-five gallons of water, should be used. This can be used only when the tree is not in foliage.

The second spraying should be with Bordeaux mixture and insecticide, to catch the early leaf-feeding insects, applied after the leaf buds have opened, but before the trees have bloomed. Never spray while a tree is in blossom.

The next spraying is the most important of all and should be given just after the petals fall, or as soon as two-thirds of the blossoms have been pollinated and have set. This spraying must be made within a few days after the blossoms fall, never more than five days later, while the calyxes or blossom ends of the apples are still open. It is this spraying which places a thin film of poison in the calyx cavity of the apple, which soon closes over it. We have seen that the young apple worms do not hatch until three or four weeks later, and that nearly three-fourths of them enter

the apple through the calyx and feed in the cavity before boring into the apple. It is therefore of the utmost importance that the calyx cavity be well filled with the poison, so that the first meal of the young worm may be his last. If the spraying be delayed until the calyx has closed, but few of the apple worms will be killed. In an experiment made in the orchard of Prof. F. W. Hooper at Walpole, N. H., the past season, the spraying was unavoidably delayed until after the calyxes had closed. As a result the sprayed trees were practically as wormy as those not sprayed, though the spraying effectually checked the scab (see page 39).

FIG. 34.—Calyxes closed; too late to spray for the codling moth.

If there be much of the "brown spot" (see page 41), so common on the Baldwin, or other diseases, it will be well to spray again about ten days or two weeks after the last spraying, in the same manner, and this spraying will usually be found profitable where it can conveniently be made.

Spray next (whether the last, or fourth, spraying is given or not) about three weeks after the blossoms fall. It is at this time that the apple worms are hatching and some will be killed by the poison on the foliage, and it is this spraying which most effectually controls the "brown spot" of the Baldwin, and other varieties.

Further sprayings will not usually be necessary unless the fruit be attacked by bitter rot, when two more sprayings at intervals of ten days should be given.

If but two sprayings can be given, spray just after the blossoms drop and three weeks later, but apply the two sprayings before the blossoms open if possible.

How to Apply the Spray.—The spray should be applied from four sides of each tree as it is impossible to cover all parts of the tree from two points. In orchard work, drive to the interval between four trees and spray one fourth of each, proceed to the next interval and repeat the operation and so on. Then, by coming back on the next row, the other side of one row is sprayed and each tree has been sprayed from four sides. The first two sprayings before the trees bloom are principally against the diseases, and for them a nozzle should be used which will throw the finest possible spray and evenly cover the foliage with a thin film. The finer the spray, the less mixture is used and the better the foliage is coated. The spraying just after the petals fall is the principle one against the apple worm and must be directed from above the fruit with considerable force, so that the spray will be driven into the open calyxes. A nozzle giving a strong spray, leaving the nozzle in a good stream and making a spray with more force, is therefore desirable. Nozzles attached to the extension rod so as to form an angle of 30 or 40 degrees to the rod, will be found serviceable for this spraying. For the last two sprayings, a fine mist, as for the first two, is desirable. Do not try to spray against a strong wind. Spray from the windward

FIG. 35.—"The day of the sky-scraper tree is passed."

side and wait till the wind shifts, or a calm day, to spray the other side.

It is evident that it is difficult to spray either the old tree soaring skywards for thirty feet, valuable only in that it furnishes a home to the friendly woodpecker, for it costs more to pick the fruit from it than it is worth, or trees scattered over a rough pasture, or following a stone wall along the roadside, where a ditch or bank often makes it impossible to reach them from the roadway. For successful spraying, as well as for proper care in culture, etc., the orchard should be in rows and the trees should be kept headed in, so that the tops can be readily reached. The day of the sky-scraper tree is passed.

Is the Spray Dangerous?—The question is often asked whether the spray on the apples is not dangerous, or whether that on the grass beneath the trees will not poison stock. Repeated experiments and analyses of apple parings have shown that one would need to eat several pecks of fruit at a sitting to secure sufficient poison for ill effects. Cattle and horses have been allowed to graze the grass beneath sprayed trees without apparent effect. Of course, the spray material should not be dumped out on the grass in any quantity, or where poultry will get it, but the ordinary drip from the trees is harmless.

Cost of Spraying.—In the records of our experiments we have shown the profit from spraying and have stated the cost at about 12 or 13 cents a tree for two sprayings. The chief cost in spraying is the labor and no definite figures are therefore possible for trees scattered over a pasture or along roadways, etc.; but where they are in orchards, the following figures give the actual cost from records made by us for several seasons and corroborated by hundreds of growers throughout the country. Indeed, many are spraying with power sprayers for half this cost per tree.

Material.

Bordeaux Mixture.		
3 pounds copper sulfate at 8c	$0.24	
4 pounds lime at 1c	.04	
		$0.28
Arsenate of lead, 2 pounds at 20c., or Paris green, ½ pound at 25c		.40
Total cost of spray material per barrel		$0.68
One barrel (50 gallons) covers 20 20-year-old apple trees, or cost of material per tree		.034

Labor.

Two men at $1.50 per day	$3.00	
One horse at $1.50 per day	1.50	
		$4.50
Will cover 150 trees per day, or labor per tree		0.03
Total cost per tree for one spraying		$0.064
Cost of first spraying with copper sulfate only		.038
Total cost of four sprayings per tree		.23

Can I Afford Not to Spray?

Profit from Spraying an Orchard of 100 Trees.

Average gross profit per tree, based on above experiments (see pages 26–33) at $1.25		$125.00
Four sprayings at 23c., or say 25c. per tree	$25.00	
20% on $40 invested in the best outfit	8.00	
		33.00
Net profit		$92.00
Less cost of outfit		40.00
Net profit for first year (80% on total investment)		$52.00

Can you make money more easily?

Fig. 36.—"It is difficult to spray trees . . . following a stone wall."